Designation: ~~F870 – 94 (Reapproved 2016)~~ F870 – 23

Standard Practice for Tread Footprints of Passenger Car Tires Groove Area Fraction and Dimensional Measurements[1]

This standard is issued under the fixed designation F870; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice covers a technique for measuring the groove or void area of a tire tread pattern. The void area is measured on the inked impression of a tire tread statically loaded against heavyweight paper on a load platen.

1.2 This procedure is intended to serve as a reference practice for measuring groove or tread pattern void areas in a tire-footprint impression. This technique is usable by any laboratory without special equipment although more sophisticated procedures are also commonly employed, such as optical or video camera processes.

1.3 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate ~~safety and health~~safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

F538 Terminology Relating to Characteristics and Performance of Tires

3. Terminology

3.1 *Definitions:*

3.1.1 *circumferential line, n—on a tire*, any real or imaginary circle on the surface of a tire, lying in a plane that is perpendicular to the spin axis. **(F538)**

3.1.2 *developed footprint length,* [*L*],*n*—the maximum footprint dimension in the circumferential direction of the tire, under stated conditions of measurement.

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[1] This practice is under the jurisdiction of ASTM Committee F09 on Tires and is the direct responsibility of Subcommittee F09.30 on Laboratory (Non-Vehicular) Testing.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

3.1.3 *developed footprint width,* [*L*],*n*—the maximum lateral dimension of a tire footprint under stated conditions of measurement. (**F538**)

3.1.4 *element, n*—an isolated (totally bounded by void) projection. (**F538**)

3.1.5 *footprint area,* [L^2],*n*—the gross contact area of a tire that is loaded (under stated conditions) against a smooth flat surface. (**F538**)

3.1.6 *groove, n*—a void that is relatively narrow compared to its length. (**F538**)

3.1.7 *groove (void) area,* [L^2],*n*—that portion of tire footprint area that is not contacted by ribs or elements.

3.1.8 *groove (void) area fraction,* [*nd*],*n*—the ratio of the groove (void) area to the footprint area of a tire. (**F538**)

3.1.9 *kerf, n*—synonym for sipe. (**F538**)

3.1.10 *lateral groove, n*—a groove that has its long dimension oriented at direction non-parallel to the tire circumferential centerline; it most frequently opens into a void at both ends. (**F538**)

3.1.11 *notch, n*—a groove smaller in both width and length than a lateral groove, that contains one closed end. (**F538**)

3.1.11.1 *Discussion*—
For the purpose of this practice, it is wider than 1 mm and more than 25 % as deep as a groove in the same tire (see Fig. 1).

3.1.12 *projection, n*—a pavement contacting area of the tread band, bounded by void. (**F538**)

3.1.13 *rib, n*—a continuous circumferential projection. (**F538**)

3.1.14 *rib or element area,* [L^2],*n*—that area within the outer periphery of a tire footprint that is contacted by ribs or elements.

3.1.15 *sipe, n*—a molded or cut rectangular void that is substantially narrower than the major grooves or voids. (**F538**)

3.1.16 *total or gross-contact area,* [L^2],*n*—that area encompassed by the outer periphery of a tire footprint.

3.1.17 *void, n*—a volume (in the tread band) defined by the lack of rubber; the depth dimension of this volume may vary from point to point in (on) the tread band. (**F538**)

4. Summary of Practice

4.1 This practice is divided into two parts. Paragraph 8.1 provides a procedure to obtain a tire footprint impression. Paragraph 8.2

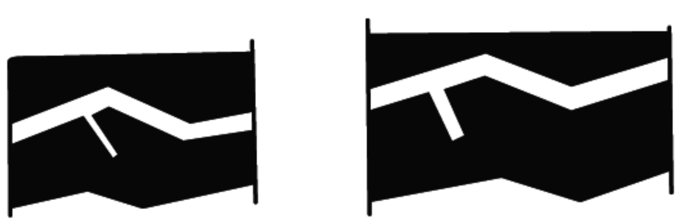

FIG. 1 Schematic Diagrams Kerf (Sipe) and Notch

describes the necessary measurements made on the footprint impression, or copies thereof, to permit a calculation of the groove-area fraction. Supplementary footprint width and length measurements may also be made.

4.2 The groove-area fraction is calculated from measurements in the central 60 % region of the footprint. This central 60 % region (calculated from footprint length dimensions) is used to avoid the ambiguities and subjective judgements in precisely defining the "ends" of a footprint. The groove area fraction, φ_A, is the ratio of the groove-void footprint area to the total or gross-footprint area in this region. The gross area can be obtained by direct measurement of this rectangular area.

5. Significance and Use

5.1 The tread of a tire, the annular band that contacts the pavement, normally contains geometric tread pattern elements that are defined by grooves or voids. These are employed to confer appropriate traction properties to the tire, mainly on wet or snow-covered roads.

5.2 One characteristic feature of tire tread patterns that is important for both traction and tire wear behavior is the percent or "fractional" groove area. The groove-area fraction is calculated with respect to the total or gross contact area.

6. Interferences

6.1 Certain difficulties may be encountered in making groove-area fraction and footprint dimensional measurements. These are principally concerned with decisions on what to include as void area. Tires are designed with a multitude of geometrical features that show up on the footprint as a void area. Section 3 addresses these problems. Subjective judgements as to what to include cannot be avoided, and where such decisions are believed to be relevant, it is necessary that sufficient explanation be made in the final report.

6.2 One typical difficulty is illustrated in Fig. 2 in defining the outside shoulder edge of the footprint in tires that do not have a continuous well-defined shoulder rib edge. The total area should be obtained by defining the edge of the print as shown in Fig. 3.

7. Apparatus

7.1 *Tire Loading Machine*—A machine or fixture that is capable of holding a rim-mounted tire vertically at normal inflation pressures and that is capable of applying a specified tire load (within ±2 %). The machine shall have a smooth, flat, hard base upon which the tire is loaded. The rate of loading shall be such that no tire bounce or oscillation occurs upon cessation of loading. Rates of vertical travel of 2 mm/s (4.7 in./min) or less in the loading operation are satisfactory.

7.2 *Ink Pad*—A soft, inked pad of sufficient area to apply ink to the surface of the tread. An office foam-rubber stamp pad used with stamp-pad ink is recommended.[3] The pad shall be inked so that the foam-pad material is fully saturated. However, avoid excess ink, which frequently causes edge distortions of the footprint impression.

7.3 *Footprint-Impression Paper*—Paper of a size sufficient to accommodate the inked footprint. The paper shall be smooth and

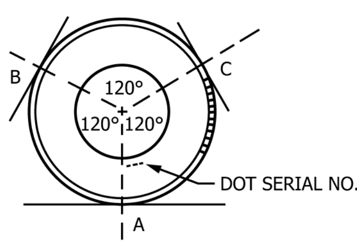

FIG. 2 Footprint Zones A, B and C

[3] A ~~Carter foam-rubber~~ stamp pad ~~No. 2 (80~~ 80 by 150 mm ~~(3 by 6 in.)) and Carter stamp pad ink No. 414, manufactured by Dennison Carter Ink Company, 321 Fortune Blvd., Milford, MA 01752, have~~ or larger, with black stamp pad ink, has been found to be satisfactory.

~~[4] Recording chart paper X-Y-1101-SPI, manufactured by Graphic Controls Corp., 189 Van Rensselaer St., Buffalo, NY 14201, has been found to be satisfactory.~~

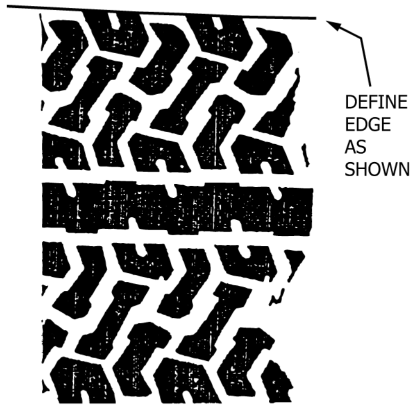

FIG. 3 Definition of Shoulder Edge in Patterns That Do Not Contain a Solid Shoulder

of sufficient ~~thickness (or weight)~~ weight (175 g per square meter or greater) to prevent surface buckling or crimping during the tire load process. The ink should not smear or penetrate beyond the geometrically defined rib areas due to capillary or other similar action.

NOTE 1—The use of pressure-sensitive paper is permissible if the user can demonstrate that the impression is clearly defined and equivalent to an inked print.

8. Procedure

8.1 *Tire Footprint Impression:*

8.1.1 Mount the tire on ~~the test rim specified by the Tire and Rim Association Yearbook~~an approved rim per the TRA Year Book or other regional tire and rim standards such as the European Tyre and Rim Technical Organization (ETRTO) or the Japan Automotive Tyre Manufacturers' Association (JATMA)[4] and inflate to the inflation pressure (see 8.1.2) for the load selected. Inspect the tread surface for irregularities, such as mold vent protrusions, and remove any found.

8.1.2 In the absence of any specific recommendations for inflation pressure, inflate to the maximum inflation pressure which is shown on the sidewall of the tire.

8.1.3 For tires with numerous mold-vent projections, buff the tread surface lightly with a power-belt sander using fine abrasive paper. Do this with the inflated tire and rim assembly mounted on a power-driven spindle rotating at 10 to 15 r/min. Apply light pressure when buffing, always moving the buffer laterally back and forth. A removal of 0.05 to 0.1 mm (0.002 to 0.004 in.) of tread surface has been found to be satisfactory. There should be no change in tread contour due to buffing.

8.1.4 In the absence of power equipment, remove the mold-vent projections or flash, or both, by applying a slight extension to the projection by hand and carefully cutting the excess from the tread face with a small, very sharp knife or pocket nail clippers.

8.1.5 Tires frequently contain tread-element dimensional variations (size, spacing, pitch, length, etc.) to reduce noise tonality in service use. When such variations exist, it is necessary to represent the tire with an average groove or void area. A recommended technique is outlined in 8.1.6. However, the recommended selection of three zones as ~~outlined~~ shown in Fig. 2 may not adequately achieve this objective, and it may be necessary to modify the location to obtain a representative set of footprint impressions.

8.1.6 Three ~~zones~~ zones, as shown in Fig. 2, are recommended for making footprint impressions. These zones, A, B, and C, are located as follows:

8.1.6.1 *Zone A,* from the DOT serial number side is defined by a plane perpendicular to a line through the center of the axis of rotation and the first letter of the DOT serial number.

[4] ~~T and RA Yearbook~~ TRA Year Book (current edition), available from ~~the~~The Tire and Rim Association, ~~175 Montrose West Ave., Copley, OH 44321.~~Inc., 4000 Embassy Parkway, Suite 390, Akron, Ohio 44333, https://www.us-tra.org; European Tyre and Rim Technical Organization, Avenue d'Auderghem, 22 - 28 Box 9 - B-1040, Brussels, Belgium, https://www.etrto.org; The Japan Automobile Tyre Manufacturers Organization, Inc., 8 Floor, No. 33 Mori Bldg., 3-8-21 Toranomon, Minato-ku, Tokyo, 105-0001 Japan, https://www.jatma.or.jp.